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Nutritional and Medicinal Quality of Pear Juice: Next Hotspot?

Ding Xie[1,2*] • Hai-yan Zhong[1] • Jianha Mo[3] • Zhong-hai Li[1] • Tao Cui[1] • Cui-ping Yi[2]

[1] Institute of Green Food, Central South Forestry University, Changsha, Hunan 410004, P. R. China
[2] Biological and Food Engineering College, Changsha University of Science and Technology, Changsha, Hunan 410076, P. R. China
[3] Yanco Agricultural Institute, NSW Department of Primary Industries, Australia

Corresponding author: * cslg5148495@126.com

ABSTRACT

With pear production increasing rapidly, the issue of why the consumption of pear juice is still far less than that of citrus and apple juice fascinates many researchers. After comparing pear with citrus and apple, particularly after analysing the factors that affect the nutritional quality of pear juice, this paper indicates that pear juice is not only a good health food with abundant Vitamin C, rich in potassium, and lower calories than citrus and apple juice, but is also a good medicine to nourish lungs, promote salivation, relieve coughs, and reduce the risk of many diseases due to its cool property and phytochemical action. In the age of the internet and genome, it is now possible to improve processing technology, and to design the nutritional recipe of pear juice to meet consumers' needs, to instruct pear planting, storing, processing and consumption effectively by integrating information from the genome to the whole body level of both humans and pears based on systems science.

Keywords: kind of pear juice, nutritional concept, nutritional genomics, pear cultivar, phytochemical component, systems science
Abbreviations: FAO, Food and Agricultural Organization; **FDA**, Food and Drug Administration; **GI**, glycemic index; **GL**, glycemic load; **ORAC**, oxygen radical absorbance capacity; **RDA**, recommended daily allowance; $\mathbf{V_c}$, Vitamin C

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INTRODUCTION

Pear is China's third most produced fruit (after apple and citrus), and is also one of the world's favourite fruits. China is the world's largest producer and consumer of pear. According to the data of Food and Agricultural Organization (FAO) in 2005, China produced 11.625 million tonnes of pear, accounting for 59.5% and 14.10% of the world total pear production and China total fruit production, respectively.

As more people gradually become healthier and become more convenience conscious, the demand for fruit juice is rising more rapidly. In 1986, China produced 15.26 million tonnes of fruit, but only 1,545 tonnes of fruit juice including 737 tonnes of concentrated citrus juice; 438 tonnes of concentrated apple juice; 6 tonnes of concentrated pear juice (China Food Industry Almanac 1987). But the total juice and juice drink comsumption increased to 5.00 million tonnes in 2004 from 0.97 million tonnes in 2000 (Beijing Zhong Shan Figure Information Technology Ltd. Co. 2006; Han 2006), equivalent to a 515% increase in weight in five years.

Although there is no data that shows the consumption of pear juice in recent years, we know that in 2005, of the 703,629 tonnes of exported fruit juice from China, 98.5% was apple juice, sharing over 50% of world apple juice trade,

Received: 11 December, 2006. Accepted: 22 January, 2007.

Invited Review

Table 1 Main functional components in pear, apple and citrus.

	Comparison of contents	Main functions	Reference
Fibre	CP＞CA~CC	Reducing the risk of heart disease and cancer, etc	**Table 3**; Honda *et al.* 1999
V_c	CC＞CP＞CA	Antioxidation, etc.	**Table 4**; Roman 1994; Chen 2005; Zhang 2005
K	CP＞CC~CA	An excellent source of potassium for maintain metabolism	**Table 5**; Finch *et al.* 1976; Basta *et al.* 1979; Edgerton *et al.* 1979
Chlorogenic acid	CA~CP＞CC	High ORAC, reducing the risk of many diseases, slowing the aging process.	**Table 6**; Schieber *et al.* 2000; Carbonaro and Mattera 2001; Tomas-Barberan and Espin 2001; Ma 2002, 2004; McCarty 2004; Tanrıöven and Eksi 2005
Arbutin	CP＞CA＞CC	Relieving a cough, diminishing inflammation, etc.	
Flavonoid	CC＞CP~CA	High ORAC, reducing the risk of many diseases.	

CP: Content in pear; CA: Content in apple; CC: Content in citrus; >: more than; ~: approximate.

and pear juice was still less than 0.1% (Deng 2006).

Why is it that the consumption of pear juice was far less than that of citrus juice and apple juice? Xiao (1987) thought that pear juice had low acidity, an insipid flavor and was too dense when with flesh, and thus thought that most people would thus dislike it. Yao (2002) and Wu (2006) pointed out that apple juice and citrus juice are in fashion due to their abundant nutrition especially with rich Vitamin C (V_c), good color and flavor, being able to reduce the risk of cancer and many other diseases. But many researchers (**Table 1**) have indicated that the nutritional components of pear juice are as rich as those in citrus and apple juice, and we believe that the color and flavor of pear juice products and processing technology can be improved according to consumers' demands, and that the nutrition of pear juice may be the next hotspot that will drive the global pear industry.

FACTORS AFFECTING THE NUTRITIONAL QUALITY OF PEAR JUICE

The nutritional quality of pear juice can be influenced by various factors such as variety, climatic conditions, soil, water, prevention and the cure of plant diseases and insect pests, harvest practice, storage conditions, processing technology and juice classification. In addition, its evaluation can also be affected by the function of pear juice nutritional components, consumers' health status and their nutritional demands.

INFLUENCE OF PEAR VARIETY AND PLANTING CONDITIONS

Pear varieties and their nutrition in various conditions

There are over 5,000 known pear varieties grown around the world, can be classified mainly as Asian pear (crisp-fleshed and juicy) and Europe pear (soft, juicy flesh). The Asian pear is mainly planted in China, Korean and Japan, and Europe pear is cultivated mainly in Italy, USA, Spain, Argentina, Germany and Turkey (**Table 2**).

In China, over 3000 species in the genus *Pyrus*, can be sorted as into 4 series: 1) *Pyrus bretschneidleri*, including *Dangshan* pear and *Yali* pear, they which shared 35% and 22% of total China pear production, respectively; 2) *P. pyrifolia*, is the second most popular type of pear grown in China, accounting for about 30% of total pear production of China, comprising snow pear (*Pyrus nivalis)*, *Huanhua*, *Golden*, *Jinqiu* and *Housui* (from Japan) and *Niitaka* (from Korea); 3) *Ussurian* such as Beijing white pear; 4) *Pyrus communis*, or European pear such as Bartlett pear. The majority of cultivars that planted in South Korean are *Niitaka*, while in Japan the most common are the 21st pear and *Kinsui*, *Housui* and *Xinsui*.

Among European pears, *P. communis* Abate Fetel is the major cultivar in Italy. The Bartlett variety is popular in many countries, for example it shares 17% of pear production in Italy and comprises over 75% of the United States pear crop (Zhao *et al.* 2005; Yan *et al.* 2006). Other European pear varieties include Conference, d'Anjou, Bosc, Comice, Seckel, and Winter Nelis (Fang *et al.* 2003; Wang *et al.* 2003; Zhao 2005).

The nutritional components of various cultivars are different. Even the nutritional components of the same cultivar can vary according to the soil, sunlight, moisture, harvest time and cultivate management (Buwalda and Meekings 1990; Kappel and Neilsen 1994; Hu 1996; Xi 1999; Lee and Kader 2000; Tagliavini *et al.* 2003; Zhou 2004), and nutriational diagnosis can help cultivate better management.

The content of sugar, organic acid and ratio of sugar to acid (titrated acid) in pear are the factors that not only determine the flavor but also the nutritional quality of pear and pear juice. For example, during *Yali* pear ripening, the fruit total sugar and fructose increase continuously while glucose and sucrose increase little, the content of starch changed in a parabolic manner, increasing rapidly from late May to early June, peaking at the end of June, and decomposing rapidly in early July, and dropping to the lowest level at harvest time (Hu 1996; Xi 1999). The ratio of sugar to acid of high quality *Yali* pear is over 55, and in pears with same ratio of sugar to acid, the total amount of sugar and acid determines the grade of pear flavor. After reaching a peak at middle August, the content of macro- (N, P, K, Ca, Mg) and micro-elements (Fe, Zn, B, Mn, Cu) in the fruit decreased as the fruit expanded (Xi *et al.* 1997; Xi 1999).

Dangshansu pear is an especially famous fruit throughout the country in China. Due to fruit farmers' malcultivation several years ago, the local ecosystem was destroyed to some extent and nutrition was disordered in tree. The defi-

Table 2 Pear production (1000 tonnes) and cultivars in main countries in 2003-2005.

	2003	2004	2005	Average	C/W (%)	Main cultivars
World	17,833.96	18,680.51	19,539.31	18,684.59	100	There are about 76 countries in the world planting pear cultivars.
Asian	11,750.63	12,666.39	13,496.09	12,637.70	67.64	Asian pears were mainly planted in China; Japan and Korea, and
China	9,920.56	10,766.87	11,625.00	10,770.81	57.65	there are few of European pears planted in these three countries
Korea, RP	316.57	451.86	380.00	382.81	2.05	also.
Japan	365.80	351.90	361.40	359.70	1.93	
Italy	826.02	877.25	925.91	876.39	4.69	The total production of Italy; USA; Spain; Argentina; Germany;
USA	847.41	795.84	736.93	793.39	4.25	Turkey shares of about 60.54% of European pears in the world.
Spain	728.27	562.10	679.40	656.59	3.51	
Argentina	665.03	535.42	–	600.23	3.21	
German	373.60	398.00	400.00	390.53	2.09	
Turkey	370.00	320.00	340.00	343.33	1.84	

References and sources of information:
Data from FAO; Average: annual average of 2003-2005; C/W: The pear production of a country shares of that of the world. – : no data available.
Zhao 2005; Yang 2006

ciency in nutritional elements caused the quality of Dangshansu pear to drop. Liu (2003) systematically integrated different diagnoses based on the principle of fruit mineral nutriology and provided a more comprehensive and reasonable diagnosis means and tool for Dangshansu pear to deal with the problem. In order to correspondingly deal with different statuses, three measures are used in the paper: combination nutrition diagnosis through tree body and soil; combination nutrition diagnosis method based on the Profit and Loss Index (PLI) and the Diagnosis and Recommendation Integrated System (DRI S); Fuzzy nutrition diagnosis. After being tested, the system achieved its design stably and unfailingly using a PC interface, user-friendly with easy-to-study visual operation. As with an expert system, it has definite superiority.

With the help of Mufti-value theory and Fuzzy nutrition diagnosis, Zhou (2004) studied 10 species of sand pear cultivars (*Cuiguan*; *Qingxiang*; *Lubaoshi*; *Daguoshuijing*; *Yuanhuang*; *Aidang*; *Huanhua*; *Golden*; *Housui*; *Niitaka*) planted respectively in *Zhuzhou* and *Yongzhou* (about 500 kilometers between them); he observed their phenological periods, fruit qualities, growth characters, resistances to the diseases and productivity in two different place. In the diagnosis, he adopted 9 mineral elements: N; P; K; Ca; Mg; Fe; Mn; Cu; Zn. The result shows that the mineral elements of various cultivars are different. Even that of the same cultivar can vary according to the climatic conditions, soil, water, prevention and the cure of plant diseases and insect pests, and harvest practice. The paper also showed the soluble solids, sugar, acid and flavor of the fruits, As a result, Chinese pears perform better than Japanese pear and Korean pears and five varieties, *Cuiguan*, *Qingxiang*, *Lubaoshi*, *Yuanhuang* and *Aidang* have been screened because they are most suitable to the environment of Hunan Province in those ten varieties.

In order to elucidate the molecular events associated with pear (*Pyrus communis* L. cv. 'Rocha') fruit development and climacteric ripening, Fonseca *et al*. (2004) isolated cDNA clones (1364 in total) from a fruit cDNA library, a subtractive library, and constructed some high-density cDNA microarrays. The expression of these ESTs was monitored from early fruit development, through ripening, until complete fruit senescence, allowing a global coverage of the entire fruit life. Based on the similarities in transcript expression profiles ESTs were grouped in different clusters. Transcripts encoding for cell wall modifications and pigment and aroma biosynthesis were induced. Transcripts putatively involved in defence response, oxidative stress, primary and secondary metabolism, signalling and transcription regulation were also isolated. This is a promising method to select suitable cultivars to meet people's nutritional needs.

Characters of pear varieties for juice-processing

The characters of European and Asian pear were studied for juice products (George and Ronald 1990; Cao *et al*. 2003). Results showed that the juice of varieties of *Pyrus bretschneideri* Rehd. and *P. pyrifolia* (Burm.f) Nakai showed less browning, while the Housui variety (*P. pyrifolia* (Burm.f.) Nakai) hardly browned. Pear varieties with a crisp, fleshy texture can be processed for clear juice. Cloudy juice can be produced from tender and "melting" (including over-ripe) pear fruit, but some soft (tender or melting) pear fruit can also be processed into clear juice. The variation in the value of the soluble solids content of pear juice ranges from 9.1% to 18.3% (Cao *et al*. 2003; Zhang 2005). Among the processed varieties, the juicing-ratio ranked from high to low is: *P. pyrifolia* (Burm.) Nakai; *P. bretschneideri* Rehd.; *Pyrus* hybrid ; *P. communis* L.; *P. ussuriensis* Maxim. *Anli* (Cao *et al*. 2003; Zhang 2005) (*P. ussurieasis* Maxim.) was very suitable for juice-processing because of its high soluble solid content, high titratable acidity, high percentage of juice-producing; the trees are very productive, resistant to diseases, and show good storability and shipping quality (Cao *et al*. 2003; Zhang 2005). The ability of Housui not to brown is valuable to research the browning mechanism at the molecular level.

KINDS OF PEAR JUICE AND PROCESSING

Pear cans, cloudy pear juice and pear juice with flesh

Pear cans: Pear halves, sliced or diced pear that is either peeled or unpeeled, packed in pure water or extra light or heavy syrup can be produced to various canned products. In general, it is not regarded as a kind of pear juice, but is similar to juice with flesh, as a major kind of pear product.

Cloudy pear juice: Is usually processed in the following flow (Ni 1999): fresh fruits → washing → breaking → squeezing → aroma callback (collecting the aroma from processing and adding to the juice again) → enzyme disposal → degassing → homogenizing → pasteurization → (vacuum and low-temperature concentrating) → finished product.

Pear juice with flesh: is made from mashing pear fruit or concentrated pear jellies and jams in water or light or heavy syrup.

All of the above are the most abundant nutritional products, since they retain nearly all nutritional components of fresh pear.

Clarified pear juice, concentrated pear juice and pear juice drink

The raw material of clear pear juice is fresh, mature pear. After washing, choosing, mashing, pressing, enzyme treatment and clarification, ultra-filtration and pasteurization, the pure, natural product is finally made. While concentrated product from clarified pear juice is in fact concentrated pear juice both products include all of the most valuable nutriational components of fresh fruit. Not only can they be consumed directly, but can also be used to produce pear nectar, carbonated drinks and some cool drinks, or be mixed with other function material such as chrysanthemum; liquorice; caladium to nurish lungs or relieve a cough (Ma 2002; Chen *et al*. 2005). One hundred percent fruit juice or reconstituted juice can be a healthy part of the diet when consumed as part of a well-balanced diet. Fruit drinks, however, are not nutritionally equivalent to fruit juice.

Effect of processing on pear juice quality

In fact, in the middle of the last century, many researchers had begun studying various pear products such as pear juice with flesh, beverages with mashed pear, clear pear juice, mashed pear and dense pear jams, and the factors which affect the quality of the final pear product, including the stability of mashed pear in stores, volatile compounds of pear, polyphenoloxidase and pheonic compounds in pear, pink discoloration in pear mud, gluten and enzymes in pear, organic acids of pear (Xiao *et al*. 1987).

Browning is an important factor which affects the quality of pear juice. Wu *et al*. (1992) analysed the biochemical mechanism and substances that determine enzymic browning of *Yali* pear (*P. bretschneideri rehd*). Li *et al*. (1994) and Zhang *et al*. (1999) studied the effect on browning of pear juice by different inhibitory conditions (such as sodium chloride, citric acid, absorbic acid) and Sheng (1995, 2005) researched the factors that influenced the quality of *Yali* pear juice, especially colour protection and the cooked taste of *Yali* pear juice.

Zhang (2005) studied the technology of clarification and how to protect the color of clear *P. pyrifolia* juice and the stability of the turbid juice. The results showed that 0.4 $g.kg^{-1}$ V_c could maintain the color of clarified juice as a straw yellow; juice extraction was improved from 72.6% to 80.7% under the incubation of pectinase at 50°C, 2.5 $g.kg^{-1}$, for 90 min. The dosage of pectinase is the key factor of juice extraction. In the processing of turbid juice extraction, the color of pear juice was preserved and the loss of V_c was reduced by using vacuum degassing before homogenization. Stabilizer and homogenization could improve the stability of turbid pear juice. The optimum concentration of the stabilizer was 0.20% (sodium carboxymethyl), or the mixture of xanthan gum and CMC-Na was 0.05% and 0.15%, respectively. Homogenization was carried out at 24000 rpm for 4 min. Sterilization was performed at 121°C for 30 s.

NUTRITIONAL COMPONENTS AND FUNCTION OF PEAR JUICE

"A knowledge of the chemical composition of foods is the first essential in dietary treatment of disease or in any quantitative study of human nutrition." (McCance and Widdowson 1940). This statement is as true now as it was in 1940. At present, thanks to the development of computerized compositional databases, we are able to obtain adequate and reliable food composition data of some pear, orange and apple juice from the USDA National Nutrient Database for comparing with the data of some Chinese research groups as appears in **Tables 3-8**.

Pear and pear juice are traditionally used for treating bladder problems, liver constipation and prostate toxin elimination because they are a good source of phosphorus, potassium, Vitamins A, B-1, B-2 and C, folic acid, pectin and dietary fibre yet they have no cholesterol and are low in calories (Jiang Su Medicine College 1986).

The nutritional composition and content of pear juice differs depending on the product, and the content of the main nutritional component varies even within the same cultivar from different producing areas, and of course also differs from either orange or apple juice (Zhou 2004; Chen 2005; Zhang 2005) However, there is no significant difference between them in terms of being an excellent source of V_c and potassium (**Tables 3-8**). But there are some kinds of pear juice such as those with flesh that can offer more dietary fibre and some functional phytochemicals worthy of further research (Ma 2004).

Calories and macronutrients (Table 3)

Sugar and organic acid

The carbohydrates in a cup of pear juice are low on the glycemic index (GI) and have a low glycemic load (Foster-Powell *et al*. 2002). This basically means that the carbohydrates in pears are slow to convert to sugar and enter the bloodstream. Pears are a good choice for obtaining healthy carbohydrates (Low GI). Fructose was the dominant sugar in pear juice followed by glucose and sucrose, and the content of deoxidized sugar was also an important index to identify whether the product is pure juice or a fake. Organic acid was the main flavor and nutrient component, while malic acid was the principal organic acid. The main pheonolic acid was chlorogenic acid, which can promote the digestion of food, and also soften blood vessels and lower cholesterol content.

Dietary fibre (Table 3)

Pears and their juice are an excellent source of natural dietary fibre. One pear (about 166 grams) will yield about 24% of the recommended daily allowance (RDA) of fibre for persons on a 2,000-calorie diet (according to U. S. Food and Drug Administration (FDA) guidelines). Fibre contains no calories, and is a necessary element of a healthy diet as it helps sustain blood sugar levels and promotes regularity (Tillotson *et al*. 1997). Pectin is a type of soluble fibre that binds to fatty substances in the digestive tract and promotes their elimination, and which seems to help lower blood cholesterol levels (American Dietetics Association 2006). Soluble fibre also helps regulate the body's use of sugars. Studies indicate that diets high in fibre may reduce the risk of heart disease and certain types of cancer (Honda *et al*. 1999; Harvard School of Public Health 2006).

Vitamins (Table 4)

Pear juice is a good source of V_c, which is an essential antioxidant for normal metabolism and tissue repair, and helps prevent free radical damage (destructive by-products of the body's metabolic process). V_c promotes healing of cuts and bruises and helps guard against a number of infectious diseases. V_c was shown to reduce the levels of C-reactive protein, a marker of inflammation and chronic disease risk in humans (Roman 1994; Thomas *et al*. 1995; Macias-Matos *et al*. 1996).

Mineral elements and trace elements (Table 5)

Mineral elements and trace element composition were identified in each pear juice. Potassium content was the highest followed by magnesium, calcium and sodium. The pear fruit composition differed according to variety. Potassium in 100 ml of pear juice offers over 10% of the RDA (2000 mg of potassium) per serving. Potassium is an important electrolyte needed for proper heart, nerve and muscle functioning and it also helps regulate water and electrolyte levels as well as help maintain carbohydrate and protein metabolism (Finch *et al*. 1976; Basta *et al*. 1979; Edgerton *et al*. 1979).

Phytochemicals (Table 6)

Chinese are always consuming pears as a health food or as good medicine to treat some diseases since ancient times. According to Li Shi-zheng's *Compendium of Materia Medica*, pear was characterized as a sweet and cold thing, has a remedial function such as nourishing the lung, cooling the heart, eliminating phlegm, lowering the evil fire, and dispelling noxious substances that arise after drinking alcohol (Jiang Su Medicine College 1986), and Chinese doctors have applied this principle to treat diseases. For example, the famous Chinese medicines, supernature pear paste (*Tian xiao de yao li gao*) and pear paste candy (*Li gao tang*), are used to nourish the lung, promote salivation, relieve coughing and eliminate phlegm are made from *Youqiu* pear.

Nowadays, many researchers indicated that pear and pear juice contain phytochemicals including phenolic constituents such as chlorogenic, arbutin, caffeic, *p*-coumaroyl quinic and *p*-coumaric acides, and a number of procyanidins and flavonol glycosides (Schieber *et al*. 2001; Petkou *et al*. 2002; Ma 2004; Tanrıöven and Eksi 2005). They have a high ORAC (Oxygen Radical Absorbance Capacity) rating. A phytochemical is a natural plant substance that works with nutrients and dietary fibre to protect against disease. Research suggests that phytochemicals work together and with other nutrients found in fruits, vegetables and nuts and may help slow the aging process and reduce the risk of many diseases, including cancer, heart disease, stroke, high blood pressure, cataracts and urinary tract infections (Arai *et al*. 2000; Shi 2000; Chan *et al*. 2005; Leontowicz *et al*. 2005). ORAC is a way of expressing a measure of the antioxidant activity of food and measures the power of antioxidant. Antioxidants help prevent damage caused by free radicals, which are by-products of reactions between oxygen and foods when energy is created. Free radical damage increases when diets are antioxidant-poor; with calorie intakes in excess of that needed caused by smoking, alcohol consumption, and the use of drugs, and also during aging and illness. Free radicals 'consume' antioxidants, which should be replaced by eating foods high in antioxidants in order to prevent disease.

Various factors have to be considered in the evaluation of the antioxidant constituents of fruits and vegetables, such as variety, agronomic factors, maturity, harvesting methods and postharvest handling procedures (Carbonaro and Mattera 2001; Tomas-Barberan and Espin 2001; McCarty 2004;

Table 3 Proximates in juice of pears, oranges and apples (amount in 100 g of edible portion).

	Housui	Yali	Dangshan	Bartlett	Pear 09254	Orange 09206	Apple 09106
Water (g)	89.02	88.30	85.80	86.1	86.47	88.30	87.93
Energy (kcal)	48	43	43	45.89	50	45	47
Protein (N*6.25)/g	0.22	0.22	0.21	0.4	0.34	0.70	0.06
Fat (g)	0.2	0.2	0.1	0.2	0.07	0.20	0.11
Carbohydrate, by difference (g)	10.0	11.1	12.9	12.9	12.94	10.40	11.68
Fibre: total dietary (g)	1.8	1.1	–	2.2	1.6	0.2	0.10
Fructose (g)	4.19	3.50	5.56	–	5.80	–	5.60
Gluctose (g)	1.91	3.39	2.57	–	3.30	–	2.50
Sucrose (g)	0.43	0.84	0.47	–	0.60	–	1.70
Total sugar (g)	9.00	8.09	8.60	12.0	9.7	8.40	10.90
Total acid (g)	0.15	0.18	0.14	0.36	–	–	–

References: Data of *Housui*, *Yali* and *Dangshan* from Zhang (2005) and Chen (2005); data of Bartlett Pear from www.poptool.net; data of Pear 09254, Orange 092506 and Apple 09106 from www.ars.usda.gov/nutrientdata. – : no data available

Table 4 Vitamins in juice of pears, oranges and apples (mg/100 g).

	Housui	Yali	Dangshan	Bartlett	Pear 09254	Orange 09206	Apple 09016
Vitamin C	3.85	3.40	11	11	1.6	50.0	0.9
Thiamin	0	0.03	0	0.03	0.011	0.09	0.021
Riboflavin	0.01	0.03	0.02	0.05	0.011	0.03	0.017
Nicacin	0.5	0.2	0	0.2	0.200	0.400	0.100
Pantothenic acid	–	–	–	–	0.022	0.190	0.063
Vitamin B-6	–	–	–	–	0.014	0.040	0.030
Folic, total	–	–	–	–	0.01	0.30	0
Folic, acid	–	–	–	–	0	0	0
Folate, food	–	–	–	–	0.01	0.30	0
Folate, DFE	–	–	–	–	0.01	0.30	0
Choline, total	–	–	–	–	0	0	0
Betaine	–	–	–	–	0	0	0
Vitamin B-12	–	–	–	–	0	0	0
Vitamin A, RAE	–	–	–	–	0	0.01	0
Retinol	–	–	–	–	0	0	0
Vitamin E	0	0.31	1.82	0.52	0.08	0.04	0.01
Tocopherol, β	0	0.16	0.57	0.23	–	–	–
Tocopherol, γ	0	0.15	0.61	0.23	–	–	–
Tocopherol, δ	0	0	0.64	0.06	–	–	–
Vitamin D	0	0	0	–	–	–	–
Vitamin K	0	0	0	–	0.3	0.001	–

References: Data of *Housui*, *Yali* and *Dangshan* from Zhang (2005) and Chen (2005); data of Bartlett Pear from www.poptool.net; data of Pear 09254, Orange 092506 and Apple 09106 from www.ars.usda.gov/nutrientdata.
DFE: Dietary folate equivalent, RAE: Retinol activity equivalent, – : no data available.

Table 5 Minerals in juice of pears, oranges and apples (mg/100 g).

	Housui	Yali	Dangshan	Bartlett	Pear 09254	Orange 09206	Apple 09016
Ca	46.50	44.60	12.00	6.00	9	11	7
Fe	2.38	0.90	0.20	0.20	0.29	0.20	0.37
Mg	82.50	60.00	116.50	2.00	7.00	11	3
P	9.50	14.00	12.00	5.00	12.00	17	7
K	239.00	990.20	137.40	145.00	96.00	200	119
Na	4.50	1.50	0.20	1.00	4.00	1	3
Zn	0.90	0.25	0.21	0.02	0.09	0.05	0.03
Cu	0.92	0.50	0.40	0.07	0.05	0.044	0.022
Mn	0.40	0.11	0.30	0.03	0.03	0.014	0.113
Se	0	0.28	0.37	0	0.0	0.1	0.1

References: Data of *Housui*, *Yali* and *Dangshan* from Zhang (2005) and Chen (2005); data of Bartlett Pear from www.poptool.net; data of Pear 09254, Orange 092506 and Apple 09106 from www.ars.usda.gov/nutrientdata. – : no data available

Tanrıöven and Eksi 2005). For instance, Galvis Sanchez *et al*. (2003) pointed out that the peels of red Anjou are rich in anti-oxidation components, and in generally, the peel of red pears include more ORAC than other kinds of pear.

Other functional components (Tables 7, 8)

The C16:0, C18:0, C18:1, C18:2 and C18:3 fatty acids were clearly the most abundant fatty acids. and the C18 family comprised more than 70% of the total fatty acids content. Asparagine and serine were the principal amino acids.

Nutritional quality of pear juice and nutritional genomics

The relativity and systematicness of pear juice quantity should be considered in its objective evaluation. Although many people have obtained health benefits as a result of drinking fruit juice including pear juice on a regular basis, some people such as puerperal woman, persons with spleen deficiency, bellyache, stomach cold and vomiting or children after Chicken-pox should not drink pear juice (Jiang Su Medicine College 1986). Some researches saw that fruit juice offers no nutritional benefit for infants younger than 6 months (American Academy of Pediatrics 2006). Variety is also important because it is said that if you have the same food every day for more than 4 days in a row, then your body will create an allergic reaction to the food. Juice is not appropriate in the treatment of dehydration or management of diarrhea (American Academy of Pediatrics 2006). Excessive juice consumption may be associated with malnutrition (overnutrition and undernutrition). Eating too much pears juice may result in some intestinal discomfort, flatulence, and tooth decay because pears contains a small amount of

Table 6 Phytochemicals in pear, apple and citrus (μg/g).

Fruit/cultivar		Chlorogenic	Arbutin	Ferulic acid	*p*-Coumaric acid	Caffeic acid	Total phenolics	Phloridzin	Hesperidin	Flavonoid
Housui	W	16 ± 2	182 ± 11	–	–	–	–	–	–	–
	P	66 ± 1	159 ± 77	–	–	–	–	–	–	–
	C	350 ± 44	532 ± 24	–	–	–	–	–	–	–
	F	–	12 ± 3	–	–	–	–	–	–	–
	J	53 ± 3	–	–	–	–	70 ± 4	–	–	–
Yali	W	226 ± 11	400 ± 22	–	–	–	–	–	–	–
	P	383 ± 17	1189 ± 7	–	–	–	–	–	–	–
	C	446 ± 46	296 ± 36	–	–	–	–	–	–	–
	F	63 ± 5	29 ± 4	–	–	–	–	–	–	–
	J	149 ± 3					161 ± 1	–	–	–
Green Bartelette	W	487 ± 11	101 ± 50	–	–	–	–	–	–	–
	P	1602 ± 8	1294 ± 37	–	–	–	–	–	–	–
	C	1467 ± 103	359 ± 31	–	–	–	–	–	–	–
	F	167 ± 4	64 ± 24	–	–	–	–	–	–	–
	J	–	–	–	–	–	–	–	–	–
Spanish pears	PF	–	–	11.2 ± 1.1	38.7 ± 3.1	189.1 ± 17	–	–	–	–
	P	–	–	14.5 ± 1.2	51.7 ± 4.5	245.2 ± 19.3	–	–	–	–
Spanish apples	PF	–	–	112.2 ± 9.1	369.2 ± 32.1	1994.1 ± 99.2	–	–	–	–
	P	–	–	134.8 ± 1.3	523.7 ± 43.7	2599.1 ± 173	–	–	–	–
Jonagold apple	P	450	–	–	–	–	–	910	–	–
	J	32	–	–	–	–	–	1.4	–	–
Navel orange	P	–	–	–	–	–	–	–	27474	3.5×10^5
	F	–	–	–	–	–	–	–	7950	0.85×10^5

References: Data of *Housui*, *Yali*, Green Bartelette from Ma (2004) and Chen (2005), values are mean ± SE of three measurements. Data of Spanish pear and apple from Gorinstein *et al*. (2002), values are mean ± SD of six measurements. Data of Jonagold apple from Schieber *et al*. (2000). Data of Navel orange from Ma (2002). W: Whole fruit; P: peel; C: corn; F: flesh; PF: peeled fruit; J: juice from whole fruit; –: no data available.

Table 7 Lipids in juice of pears, oranges and apples (g/100 g).

	Housui	Yali	Dangshan	Bartlett	Pear 09254	Orange 09206	Apple 09016
Fatty acids, total saturated	0.028	0.029	0.028	–	0.004	0.024	0.019
12:0	0.001	0.001	0.001	–	0.000	0.000	0.000
14:0	0.000	0.000	0.001	–	0.000	0.001	0.001
16:0	0.023	0.023	0.025	–	0.003	0.021	0.015
17:0	0.001	0.001	0.000	–	0.000	–	0.000
18:0	0.002	0.003	0.001	–	0.000	0.001	0.002
20:0	0.001	0.001	0.001	–	0.000	–	0.000
Fatty acids, total monounsaturated	0.003	0.014	0.007	–	0.014	0.036	0.005
16:1 undifferentiated	0.001	0.001	0.000	–	0.000	0.005	0.000
18:1 undifferentiated	0.002	0.013	0.007	–	0.013	0.032	0.004
20:1 undifferentiated	0.000	0.000	0.000	–	0.000	0.000	0.000
Fatty acids, total polyunsturated	0.071	0.006	0.070	–	0.015	0.040	0.033
18:2 undifferentiated	0.067	0.054	0.069	–	0.015	0.029	0.033
18:3 undifferentiated	0.003	0.004	0.001	–	0.000	0.011	0.006
20:4 undifferentiated	0.001	0.002	0.000	–	0.000	0.000	0.000
22:5 undifferentiated	0.000	0.000	0.000	–	0.000	0.000	0.000

References: Data of *Housui*, *Yali* and *Dangshan* from Zhang (2005) and Chen (2005); data of Bartlett Pear from www.poptool.net; data of Pear 09254, Orange 092506 and Apple 09106 from www.ars.usda.gov/nutrientdata. – : no data available

sorbitol, a sugar alcohol the body cannot process but bacteria in the digestive system can break down for energy (Hyams *et al*. 1988; Lifshitz *et al*. 1992; Ament 1996).

In a word, there are many factors which influence the nutritional quantity of pear juice. Even more, the evaluation of pear juice nutrition quality is also related to a person's state of health and nutritional concept, since a consumer with a special nutritional state and body function will have different needs for special kinds of pear juice and various contents of nutritional components.

At present, many nutritionists use special software to accomplish various assignments and to obtain information on food composition, analyse diet notes, pick up information from gene banks and build related theories to analyse the effect of nutrients on the metabolic system. Medicine literature supplies a biodynamic database with loose sorting to establish some theories on how to control or alleviate chronic diseases such as diabetes, cancer, and obesity (Della Penna 1999; Bowman and Russell 2001).

In the age of the internet and postgenomics, we are able to integrate all the information from the genome to the whole body level of both humans and pears based on a systems science approach, and to improve the nutritional prescription of pear juice products and processing technology according to the development of science, variation in nutritional concepts and consumers' demands, and subsequently provide advice on how to culture, store and consume pear.

SUMMATIVE CONCLUSIONS

The present review paper summarized the factors that influence the nutritional quality of pear juice based on the concept of systems science. 1). The nutritional components of the same cultivar vary according to different soils, sunlight, moisture, harvest time and cultivation management. Nutritional diagnosis can help cultivate management; 2) The nutritional components, storage property, and juicing characteristic of various cultivars are different. The peels of red Anjou are rich in anti-oxidation components, while *Anli* pear and *Housui* are very suitable for juicing-processing. 3) There are differences in nutrition among different kinds of pear juice. Processing technology also influences the nutritional component of pear juice. Fruit drinks are not nutritionally equivalent to fruit juice, while a pear juice mixture with a nutrition fortifier can meet some people's special needs. But there are no significant differences in benefit to people between pear, orange and apple juice, and the func-

Table 8 Amino acid in juice of pears, oranges and apples (mg/100 g).

	Housui	Yali	Dangshan	Bartlett	Pear 09254	Orange 09206	Apple 09016
Tryptophan	–	–	–	–	0	2	–
Threonine	1	2	2	–	9	8	–
Isoleucine	2	1	1	–	10	8	–
Leucine	1	0	1	–	17	13	–
Lysine	0	0	1	–	12	9	–
Methionine	1	0	1	–	4	3	–
Cystine	1	1	2	–	3	5	–
Phenylalanine	1	0	1	–	9	9	–
Tyrosine	1	0	1	–	3	4	–
Valine	3	2	1	–	12	11	–
Arginine	1	0	1	–	6	47	–
Histidine	1	1	1	–	4	3	–
Alanine	4	3	3	–	11	15	–
Aspartic acid	58	12	55	–	68	75	–
Glutamic acid	0	0	0	–	25	33	–
Glycine	0	0	0	–	10	9	–
Proline	2	5	4	–	9	44	–
Serine	80	67	203	–	12	13	–
Hydroxyproline	0	0	0	–	–	–	–
Total	157	94	278	–	214	311	–

References: Data of *Housui*, *Yali* and *Dangshan* from Zhang (2005) and Chen (2005); data of Bartlett Pear from www.poptool.net; data of Pear 09254, Orange 092506 and Apple 09106 from www.ars.usda.gov/nutrientdata. – : no data available

tion of phytochemicals within them is worth researching further; 4) Evaluation of nutritional quality is also related to humans' state of health and to a nutritional concept. In this day and age, we can do more work on nutritional genomics of humans and pears to meet consumers' needs more effectively.

ACKNOWLEDGEMENTS

Project supported by Hunan Provincial Natural Science Foundation of China (06JJ50068).

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